Operating Instructions Rheomat R 140

Index

1 Introduction 2
2 Measurement Principle 2
3 Installation 5
3.1 Instrument Location 5
3.2 Instrument set up 5
3.2.1 Front View 5
3.2.2 Side view 6
4 The Keypad 7
5 Settings 8
5.1 Language 8
5.2 Measuring Systems 8
6 Measurement 9
6.1 Preparation 9
6.1.1 Temperature Control 9
6.1.2 Zero Adjustment 10
6.2 Measuring 10
6.2.1 Change Shearrate 11
6.2.2 Cancel Measurement 11
7 Appendix 12
7.1 User Instructions 12
7.2 Maintenance 12
7.2.1 Cleaning 12
7.2.2 Calibration and Testing 13
7.3 Erros and Malfunctions 13
7.3.1 Accessories and Order Numbers 14
7.4 Technical Data and Tables 17
7.4.1 Measuring Head R 140 17
7.4.2 DIN – Measuring Systems 18
7.4.3 Relative- Measuring Systems 19
7.5 Support / Service Request 21

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1 Introduction

The proRheo R 140 is used for simple determination of dynamic viscosity of a wide range of substances in laboratory.

The proRheo R 140 is a rotational viscometer. Its open, concentric measurement system allows measurements by immersion. Measuring head and measuring tube are rigidly coupled motor.

The torque is determined by measuring the motor current which is needed to have the measuring bob rotate in the sample at a given rotational speed. Viscosity is calculated from this torque, the given shear rate and the measuring system used.

The display shows the following data:

- the torque M mN.m,
- the shear rate D s^{-1},
- the shear stress τ (tau) Pa,
- the calculated viscosity η (eta) Pa·s,
- the measurement system, e.g. 11

2 Measuring Principle

Measuring viscosity with the R 140 is based on the SEARLE-Principle: Rotational rheometer with fixed measuring tube (or cup) and rotating measuring bob.

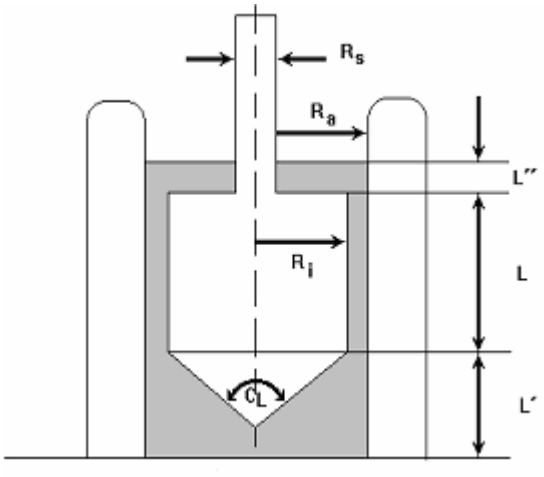


Figure 1

The measuring bob rotates at a constant rotational speed (n) in the sample. The necessary torque to keep the measuring bob rotating at a constant speed is a direct measure for the sample's viscosity.

The evaluation of rotational speed (n) and torque (M) follows according DIN 53 019.

Definitions:

Shear rate D:	Loss of speed between measuring bob and measuring tube. The shear rate is a measure for the power with which the sample is sheared in the measuring gap.
Shear stress τ:	Power which the Sample opposes to the shearing.
Viscosity η:	Proportion of shear rate and shear stress.

Measuring viscosity with the Rheomat R 140 the user determines the shear rate. Shear stress respectively torque are measured.

Viscosity is calculated as:

$$\eta = \frac{\tau}{D}$$

with:

$$\tau = \text{Ktau} * M$$

$$\text{KTau} = \frac{1+\delta^2}{2\cdot\delta^2}\cdot\frac{1}{2\pi L R_i^2 C_L}$$

$$\delta = \frac{R_a}{R_i}$$

Terms see Figure 1

Note: Frequently viscosity is not a constant but depending on the shearing. The same sample can show different viscosities at different shear rates (different measuring systems or different rotational speed)
Viscosity measurements can reach the same measurement results only at equal conditions.

Attention: Viscosity comparisons of measurement data obtained with different instrument types make sens only at measurements according DIN 53018 / 53019.

For viscosity measurement with the Rheomat R 140 the shear rate is given. The Rheomat R 140 works at rotational speeds between 5 and 1000 rpm. From this result different shear rate ranges (see Chapter 7.4.2.ff), depending on the geometry of the measuring system.

The connection between rotational speed n and shear rate D is:

$$n = D / KD \quad \text{or} \quad D = KD * n$$

with:

$$KD = \frac{1+\delta^2}{\delta^2 - 1} \cdot \frac{\pi}{30}$$

$$\delta = \frac{R_a}{R_i}$$

Terms see Figure 1

Using customized measuring systems the values KD and KTau can be calculated as shown above. These values can be stored in the Rheomat R 140 as shown in chapter 5.2.

3 Startup procedure

3.1 Location

In the lab, the stand (optional accessory) with the proRheo R 140 should be positioned on a level bench.
The Rheomat 140 can be operated at a temperature between +10 and +40 °C.

3.2 Installation

3.2.1 Front view

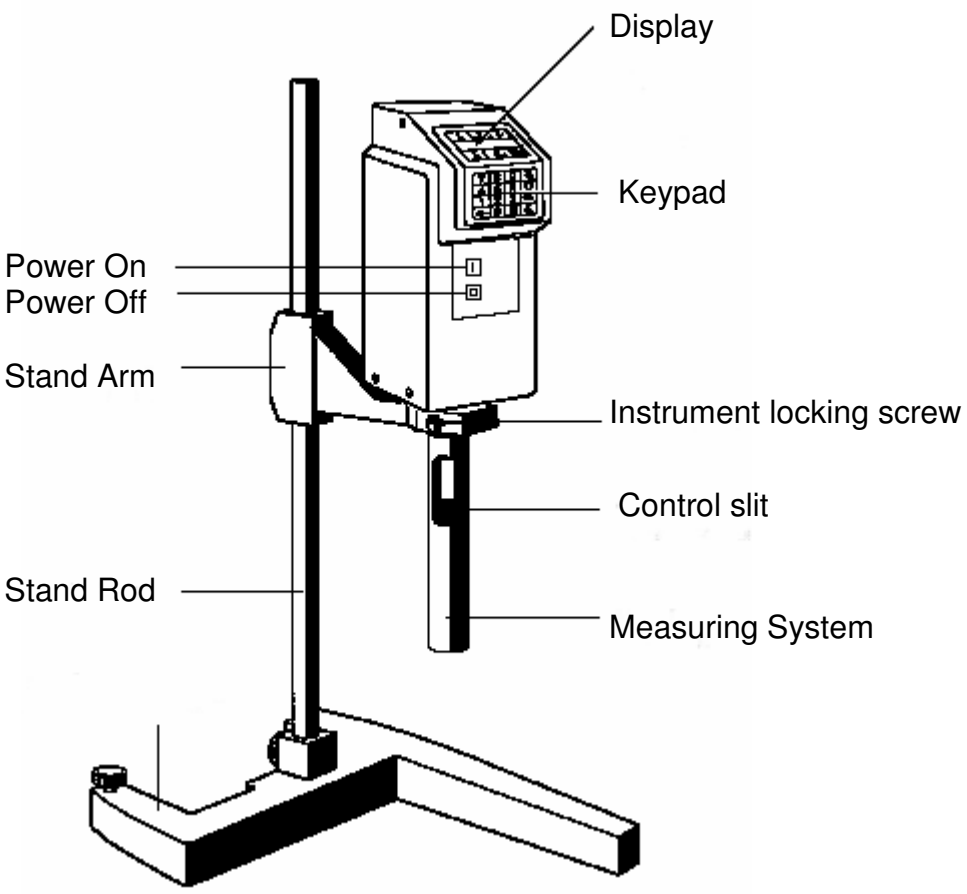


Fig. 2

- Place stand rod in stand base and secure with the screw.
- Slide stand arm unit over stand rod and secure with the screw in the desired position.
- Install the Rheomat 140 and fix with screw.

3.2.2 Side view

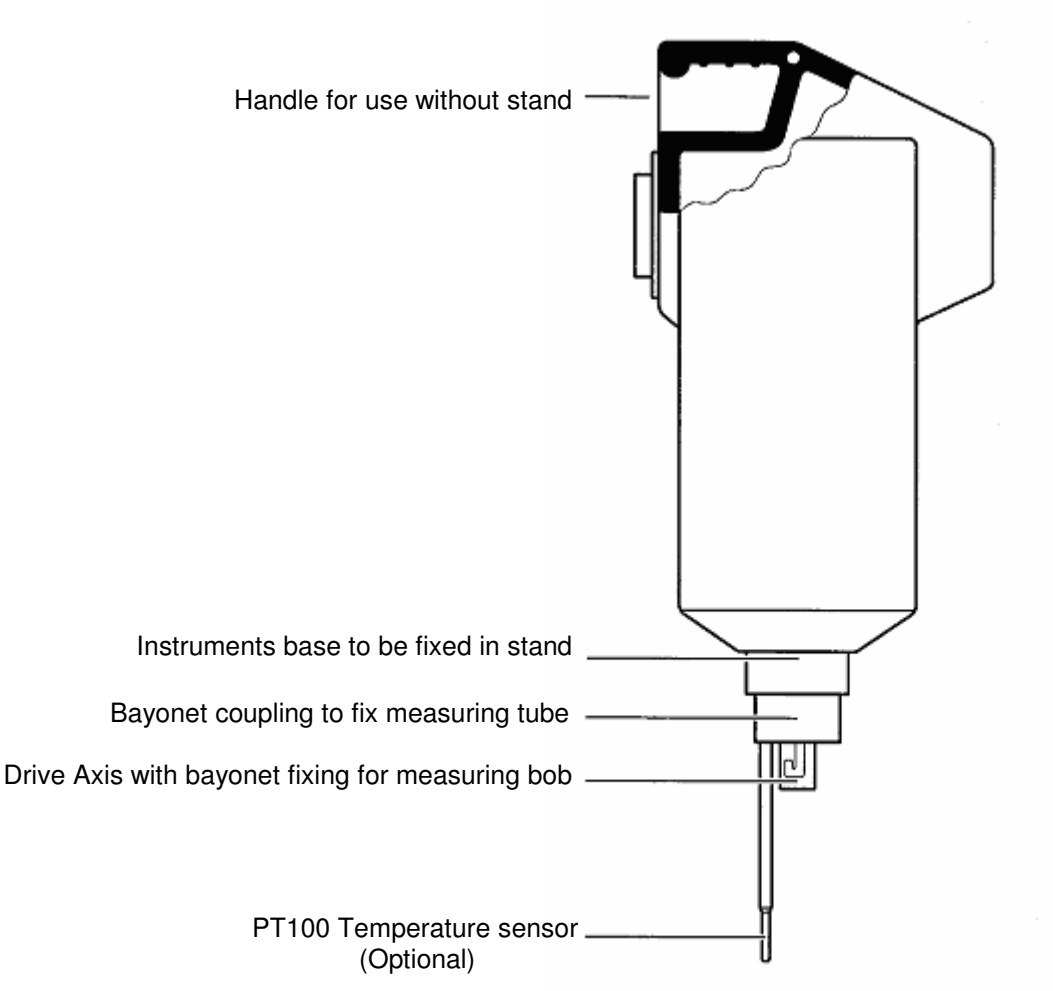

Handle for use without stand
Instruments base to be fixed in stand
Bayonet coupling to fix measuring tube
Drive Axis with bayonet fixing for measuring bob
PT100 Temperature sensor
(Optional)

Fig. 3

- Chose the measuring bob for your measurement and fix it to the drive axis (bayonet closing).

  Note: The higher the viscosity of the sample, the smaller the measuring bob to be used (see Chapter 7.4.2 and 7.4.3).

- Push the measuring tube corresponding to the measuring system over the mounting and connect.

- Switch on the instrument. Display shows: proRheo R 140

4 Keypad and Handling

Keys	Function
Numbers	Enter of numeric values
E	Confirmation of an entry
0 (Zero)	Zero adjustment (see Chapter. 6.1.2.) Press „power on“ and „0“ simultaneously. Display shows: ...› 0 ‹…
1	Definition of measuring systems (see Chapter 5.2) Press „power on“ and „1“ simultaneously. Display shows: MESSYS NR.
•	• Select Language (see Chapter 5.1) Press „power on“ and „point“ simultaneously. Display shows: LAN-GUAGE (Sprache) • Start measurement. • (Decimal-) Point during entry

The keys have different functions, depending on the mode. Please see the summary below:

Key	Entry	Function During operation	Together with ON (I)
0 ….. 9	Number		
E	Confirm		
0 (Zero)	Number		Automatic Zero adjustment
1 (One)	Number		Definition of own Measuring systems
←	Delete	Terminates measurement	
•	• (Point)	Starts Measurement	Select Language: e = 0, d = 1, f = 2, it = 3, sp = 4, hl = 5

5 Settings

5.1 Language

When you switch the proRheo R 140 on for the first time, the display is in German. To ensure that the text appears in the language most appropriate to your needs, you are offered a choice of 6 languages. Exceptions are the words LANGUAGE, CODE, TRY AGAIN and CLEAR.

- Press the hand key and at the same time switch the instrument on:
  LANGUAGE*:* appears on the display.
  Enter one of the following numbers for your language:

  - 0 English
  - 1 Deutsch
  - 2 Francais
  - 3 Italiano
  - 4 Espanol
  - 5 Nederlands

- Press the **E** key to confirm the entry.

Your language is stored by the proRheo R 180 until you define a different one.

5.2 Measuring systems

To define a measuring system the according KD- and Ktau values are stored. (see Chapter 2). The following measuring systems are already defined on delivery and can not be overwritten:

Measuring systems acc. DIN 53 018/ 53 019:	11, 22, 33
Relative systems:	12, 23
Anchor shaped systems:	71, 72, 73, 74, 75

Customized measuring systems can be used. For correct calculation of shear rate and shear stress for these measuring systems, the according factors have to be determined and entered into the Rheomat R 140. These factors can be stored under the chosen measuring system number (01 – 99, see exceptions above). For calculation of the factors KD and KTau please see chapter 2.

- Calculate the factors KD and KTau (see chapter 2).

- Press 1-Key and „power on“ simultaneously.

.

  Display: SYSTEM-NR.:
  The Numbers 01….99 are available for customized measuring systems with exception of the numbers mentioned above.

- Enter number and confirm with **E**.

  Display: KD:

- Enter value KD for shear rate and confirm with **E.**

  Display: KTAU:

- Enter value KTau for shear stress and confirm with **E**.

Note: The numbers and factors of a customized measuring system can be overwritten by entering new values..

6 Measurement

6.1 Preparation

The filling of the measuring system has to be done very carefully.

Please refer to the given filling volumes (see chapter 7.4.2 ff).

Air bubbles in the measuring gap have an influence on the measuring result.
Stirring up and filling the sample corresponds to a preshearing which can have an influence on the measuring result. An according time of rest can have positive results but eventual sedimentation should be taken into account.

6.1.1 Thermostating

In general the viscosity of a sample is depending on the temperature. Therefore we recommend using a commercial thermostat or cryostat for temperature control.

- Close the measuring tube with its cap and dip the measuring tube as deep as possible into the bath. Take care that no temperation fluid enters the sample.

With temperatures above 50 °C, you should take into consideration the heat losses due to air circulation around the measurement system as well as condensation. We advise covering the top of the thermostat bath around the measuring tube.

6.1.2 Zero adjustment

You should perform a zero adjustment with the measurement system in the absence of sample every day and after each change of the measurement system. The zero adjustment must be done under the same operating status as the following measurements. (Battery or power supply operation).

- Fix the desired measuring bob.

Attention: The measuring bob is not to be immersed into the sample!

- Press the 0 (Zero)-Key and switch on the R 140 simultaneously.

During adjustment the display shows: ...> 0 <...
When finished the display shows: proRheo R 140

Note: a) During adjustment the measuring bob turns first fast and then slowly. The measuring bob is not to be touched during adjustment.

b) The value of the zero adjustment is stored until the next zero adjustment is processed.

c) The Zero adjustment should be performed after the instrument has warmed up. Allow the Rheomat R 140 to run at a shear rate of 50 s^{-1} for approx. 30 s.

Attention: With an empty measurement system, the proRheo R 140 should not rotate faster than D = 200 s^{-1} !

6.2 Measurement

The viscosity of the sample is determined at a constant shear rate.

- Immerse measurement system without cap in the sample or add the sample to the closed measurement system (Filling volume see chapter 7.4.2).

- Switch on the Rheomat R 140 and wait until the display shows: proRheo R 140

Note: If you have to thermostat the sample, wait until the desired temperature is displayed before starting the measurement

- Press the point- key.

- Enter number of measuring system and confirm with **E.**

- Enter shear rate and confirm with **E.**

Note: a. The values/numbers for interval, measurement system and shear rate are stored, so that for the next measurement you can either confirm these with E or enter new values/numbers.

b. The shear rate range is 6.5...1291 s-1 for the DIN measurement systems 11, 22 and 33 (for other measurement systems, see chapter 7.3.4). If you enter a number outside this range, SHEAR RATE immediately reappears on the display to allow the "correct" value to be entered.

The measurement starts. You are shown the following data on the display after approx. 5 s:

- the torque M in mNm
- the shear rate D in s^{-1}
- the shear stress τ in Pa
- the calculated viscosity η in Pa.s
- the measurement system, e.g. 11.

The proRheo R 140 acquires several measured values per second and displays the recalculated mean values.

6.2.1 Change shear rate

During the measurement you can change the shear rate:

- Press one of the numeric keys (1 to 9): SHEAR RATE appears in the display.
- Enter new value and confirm with **E**.

Note: If the torque is too large (>10 mNm), you are shown the message: M TOO HIGH (M = torque). You can either enter a lower value for the shear rate or, if possible, use a more suitable measurement system.

If the torque is too low (‹0,25 mNm), you are shown the message: M TOO LOW. In this case you can enter a larger value for the shear rate or use a more suitable measurement system (see chapter 7.4.2).

6.2.2 Cancel measurement

To terminate a single point measurement, either

- press the arrow key or
- switch off the instrument.

7 Appendix

7.1 User advice

Any demands for service or warranty expire if the instrument is opened by unauthorized persons. A net connected and opened instrument can cause injuries to user's life and limb. Sensible parts and parts under voltage are not specially marked.

At no time any liquid may enter inside the measuring head R 140. This can happen e.g. if the instrument is turned upside down for cleaning purposes. The user has to take care that this does not happen.

Using a cryostat or similar instruments no steam may enter the instrument. This can cause damages. The user has to take care that this does not happen.

The R 140 measuring head may not be immersed into any liquid. The user has to take care that this does not happen.

7.2 Maintenance

Warning: The proRheo R 140 and the power supply may be opened only by qualified service engineers!
Any demands for service or warranty expire if the instrument is opened by unauthorized persons. A net connected and opened instrument can cause injuries to user's life and limb. Sensible parts and parts under voltage are not specially marked.

7.2.1 Cleaning

- If the measuring head, drive shaft coupling or stand are really dirty or badly contaminated, clean only with a cloth moistened with soapy water, gasoline or alcohol.

- To clean the measuring head and measuring tube, always uncouple these from the proRheo R 140!

- You can use appropriate solvents for the measurement systems.

- Never place the O-rings of the caps in organic solvents! Lightly grease them with silicone grease.

- At no time any liquid may enter inside the measuring head R 140. This can happen e.g. if the instrument is turned upside down for cleaning purposes. The user has to take care that this does not happen.

7.2.2 Calibrating and testing

The proRheo R 140 can be calibrated only by proRheo service. Special instruments and specialized knowledge are required.

proRheo offers service and calibration contracts. According forms are provided in the annex.

To test whether the instrument is measuring properly and/or proper measurements have been performed, you can use calibration oils for viscosity measurements.

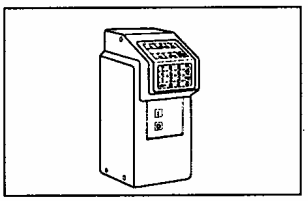
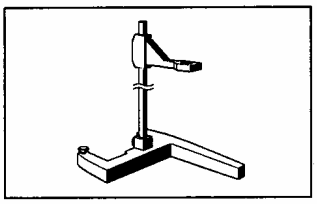
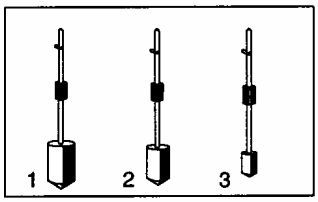
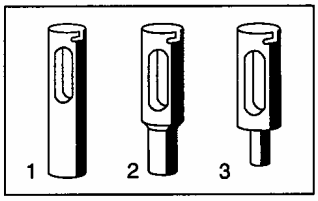
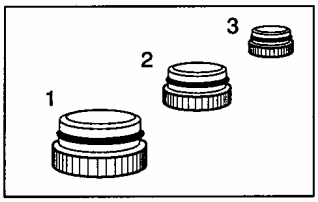
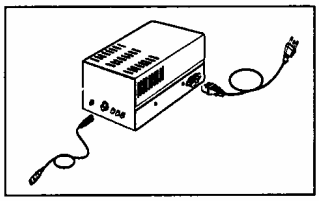
Glycerol (hygroscopic) and water (viscosity too low) are unsuitable.

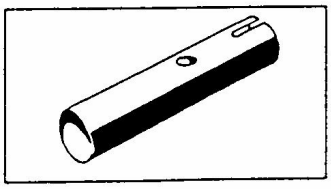
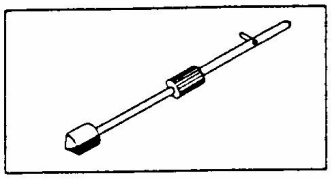
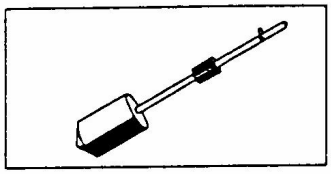
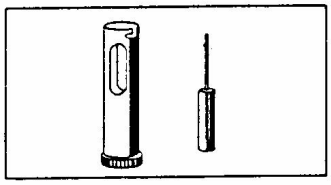
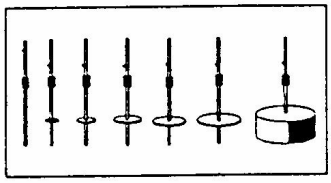
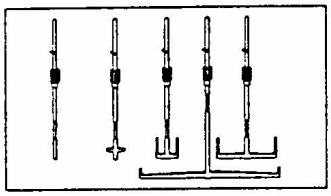
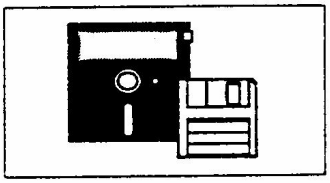
7.3 Errors and malfunctions

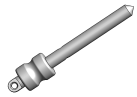
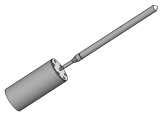
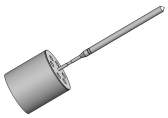
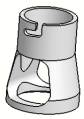
Error/malfunctions	Reason	Action
The green lamp of the power supply unit does not light up	- Not attached to power supply or power supply defective	Check power supply
The display shows › READY	- The entries are wrong or not stored correctly - Internal buffer battery is discharged	Switch off the R 140 and simultaneously press the hand key. Reselect or re-enter language and code Call ProRheo service
The proRheo R 140 switches itself off	- Power supply unit disconnected from net - Torque too high (with single point measurement)	Attach the power supply On restart, either enter lower value for shear rate or select a smaller measurement system

7.3.1 Accessories and order numbers

Standard delivery includes: measuring head, power supply, measuring tube 1 and measuring bob 2 (aluminum).

		Order-No.:
	Measuring instrument	300 0000
	Stand, comprising ▪ Stand base with adjustment screw ▪ Stand rod ▪ Stand arm with locking screw	400 0200
	Measurement system of stainless steel, comprising: Measuring bob 1 (Ø 30 mm, l = 45 mm) Measuring bob 2 (Ø 24 mm, l = 36 mm) Measuring bob 3 (Ø 14 mm, l = 216 mm)	 112820 112821 112822
	Measuring tube 1 (Ø 32,54 mm) Measuring tube 2 (Ø 26,03 mm) Measuring tube 3 (Ø 15,8 mm)	112932 112937 112938
	Cap 1 (for measuring tube 1) Cap 2 (for measuring tube 2) Cap 3 (for measuring tube 3)	112872 112877 112878
	Power supply	400 0700

		Order No.
	Measuring tube of aluminium set of 100	111 931
	Measuring bob No. 4 (Ø 14mm, l = 10,5mm) for high viscosities	111 906
	Measuring bob No. 9 (Ø 31,5mm, l = 45mm) for high shear rates and low viscosities (forms with measuring tube 1 measuring system 19)	111 875
	Double slit system MS 0 for low viscosities	112 823
	Measurement systems ISO 2555 (set)	111 948
	Measurement system TV (set)	111 949
	Software Rhesy 180 A Software Rhesy 180 S Cable RS 232 Cable USB	4000608 4000610 4010920 4010922

	Adapter VT02- Measuring systems	401 0113
	Adapter Brookfield-Messsysteme	401 0114
	Measuring bob VT 1	200 0191
	Measuring bob VT 2	200 0192
	Measuring bob VT 3	200 0193
	Measuring cup VT	200 0210
	Centering part	200 0300
	Stand for cone/plate measurements	400 0300

7.4 Technical data and tables

7.4.1 Rheomat R 140

Measurement principle	Rotational viscometer
Measuring systems	Cylindric (DIN 53 019) Cone/plate (DIN 53 019) Double gap (DIN 53 019) ISO 2555 Anchor (former TV/STV) Bells (VT)
Rotational speed	
• Range	5 to 1000 min-1
• Accuracy:	± 0,5% of entered rated value
Torque:	0,25 to 10,0 mN·m
Admissible ambient temperature	+ 10 to +40 °C
Data memory	Lithium battery, lifetime min. 3 years
Dimensions (Measuring head)	
• Width x Depth x Height	105 x 135 x 350 mm
• Weight	2,2 kg
Power supply unit	
• Voltage/current	100 - 120 V±10% / approx. 320 mA or 220 - 240 V±10% / approx. 160 mA
• Frequency	50 - 60 Hz
• Type of protection	I
• Approvals	Europe EN 60950 Electrical safety EN 55022 Interference suppression Canada CSA 22.2 No. 151-M1986

7.4.2 DIN – Measuring systems

Following DIN- Standard 53018/ 53019.

System No.	Tube ∅ mm	No	Bob ∅ mm	No.	Shear rate [s^{-1}]	Viscosity [Pa·s]	Fill volume [ml]
11	32,54	1	30	1	6,5 – 1291	0,005 – 19	Ca. 24
22	26,03	2	24	2	6,5 – 1291	0,010 – 38	Ca. 16
33	15,18	3	14	3	6,5 - 1291	0,050 – 191	Ca. 9
19	32,54		31,5	9	16,1 – 3230	0,002 – 7	Ca. 18

Cone / Plate measuring systems following DIN- Standard 53018/ 53019

System Nr.	Cone ∅ mm	Cone Angle	Shear rate [s^{-1}]	Viscosity [Pas]	Fill volume [ml]
5	50	0,5	60 – 12.000	0,005 – 4,4	ca. 0,5
6	50	2	15 – 3.000	0,010 – 17,6	ca. 1,5
7	20	0,5	60 – 12.000	0,020 – 68	ca. 0,2
8	20	2	15 – 3.000	0,070 – 275	ca. 0,5
9	70	0,5	60 – 12.000	0,002 – 1,6	ca. 1
10	70	2	15 – 3.000	0,002 - 19	ca. 3,5

Double gap system following DIN Standard 54 453

System	Tube ∅ mm	Bob ∅ mm.	Shear rate [s^{-1}]	Viscosity [Pa·s]	Fill Volume [ml]
50	28 32,54	25,81 30	6,5 – 1291	0,001 – 5	Ca. 38

7.4.3 Relative- Measuring systems

Measuring bob 2, 3 and 4 with measuring tube 1

System	Tube		Bob		Shear rate [s^{-1}]	Viscosiy* [Pa·s]
	∅ mm	Nr.	∅ mm	Nr.		
12	32,54	1	24	2	1,7 -354	0,027 – 104
13	32,54	1	14	3	0,8 – 152	0,210 – 800
23	26,03	2	14	3	0,95 - 190	0,240 - 900
14	32,54	1	14	4	0,8 - 152	0,545 – 2.080

* These values are approximate only!

Measuring bob 1,2,3 and 4 without tube (rotational speed: 5 – 1000 min^{-1})

System No. .	Bob No.	Viscosity [Pa·s]
1	1	0,020 – 76
2	2	0,048 – 182
3	3	0,340 – 1.292
4	4	0,550 – 2.090

Instead of shear rate **D** the rotational speed **n** is displayed

Systeme following ISO-Standard 2555 rotational speed: 5 – 1000 min^{-1})

System No.	Bob No.	Viscosity [Pa·s]
61	1	0,007 – 26
62	2	0,028 – 106
63	3	0,070 – 264
64	4	0,139 – 529
65	5	0,278 – 1.057
66	6	0,696 – 2.643
67	7	2,783 – 10.574

Instead of shear rate **D** the rotational speed **n** is displayed

Anchor- Measuring Systems (rotational speed: 5 – 1000 min $^{-1}$)

System No.	Bob No.	Viscosity [Pa.s]
71	1	0,003 – 10
72	2	0,027 - 104
73	3	0,160 - 605
74	4	0,665 – 2.530
75	5	2,580 – 9.800

Instead of shear rate **D** the rotational speed **n** is displayed

VT- Measuring Systems (Bells) (rotational speed: 5 – 1000 min $^{-1}$)

System No.	Bob No.	Viscosity [Pa.s]
91	1	0,035 - 123
92	2	0,900 – 3.420
93	3	0,005 - 14

Instead of shear rate **D** the rotational speed **n** is displayed

7.5 Support / Service Request

Please fill in the following and send to our fax-no.: **+49 - 7051 – 92489-29**

Company

_____

Contact person

_____

Department

_____

Telephone

_____

Fax

_____

Email

_____

Address

_____

Address

_____

Please contact us because of our Rheomat R 140

Serial number _____

We'd like to have the following information:

- ☐ Service Contract
- ☐ Service / Calibration
- ☐ Technical Inquiry